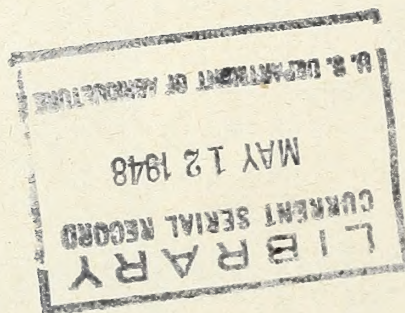
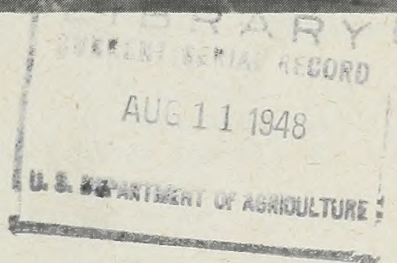


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OUTLINES

**FOR THE STUDY OF MAMMALIAN
ECOLOGY AND LIFE HISTORIES**

**WILDLIFE LEAFLET 304
FISH AND WILDLIFE SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR**



Cover;--In arid country observations can be made on many species at water holes. Bison at the National Bison Range, Moiese, Montana.

United States Department of the Interior, J. A. Krug, Secretary
Fish and Wildlife Service, Albert M. Day, Director

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OUTLINES FOR STUDY OF MAMMALIAN ECOLOGY AND LIFE HISTORIES

By Walter P. Taylor, Biologist, Division of Wildlife Research

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INTRODUCTION

Few lines of biological inquiry possess greater interest or importance than those that deal with the activities of the wild animal in its natural environment. Such studies also have a practical value (Taylor 1924). 1/

1/ Publications referred to parenthetically by date (alone or with colon and specific page) are listed in the Bibliography, pp. 23-26.

NOTE.--This leaflet is a revision of United States Department of Agriculture Miscellaneous Publication 86, Outlines for Studies of Mammalian Life Histories, issued in October 1930 by the Bureau of Biological Survey, now a part of the Fish and Wildlife Service, of the United States Department of the Interior.

The resulting data are often essential to the solution of problems in the prevention and control of animal-borne diseases, in the conservation of natural resources, and in the elimination of waste and the stimulation of production in the several branches of agriculture, including general farming, horticulture, range management, wildlife management, and forestry. "Not a single farm product but is affected directly or indirectly by some animal activity," says Osborn (1919: 112).

Life-history data are essential also to a proper understanding of the structure and classification of the mammal; they provide the student of ancient life with materials for gaining a truer and more thorough knowledge of the past; they are prerequisite to a determination of the factors controlling distribution; and they are of very practical importance in problems of wildlife development and improved land use. The advancement of agriculture depends to a large extent on a better and more scientific understanding of the relation of plants and animals to their surroundings. Hasty judgment concerning the harmful or the beneficial attributes of a mammal is often erroneous, and life-history studies are necessary for sound guidance. Effective management of mammals depends on adequate knowledge of their habits and their relations to their surroundings.

Ordinarily, mammalian life histories should be studied in relation to the entire plant and animal community in its inorganic environment. As more than one writer has emphasized, there is but one great system of matter and energy, and studies of restricted parts of the system are but for convenience. The truest, most adequate, and most satisfactory approach is through the entire biotic community (Taylor 1920 and 1935b).

THE MAMMALIAN COMMUNITY

As an important part of the biotic community, mammals should be considered from the point of view of community functions, as their origin, migration, invasion, reinvasion, and establishment. Although little attention has been given to the application to mammals of such concepts as ecological succession, reaction, interrelations, and management, these concepts should certainly not be neglected (Taylor 1920). It is unfortunate, in a way, that the mammalian community should ever have to be segregated from plants and animals as a whole in their environment. For convenience of handling, however, such segregation or restriction is sometimes necessary. The mammalogist should conscientiously and consistently strive to embrace in his view not only the mammals but also all other living creatures in the biotic community of which the mammals are parts together with the environment. Only in this way can he avoid the errors, conflicts, and wasteful practices that are the inevitable result of overspecialization and narrowness of outlook.

WILDLIFE MANAGEMENT

One of the most practical applications of biological field studies in recent years is in the relatively new sphere of wildlife management, now rapidly developing into a profession. The activities included under this heading often are of the utmost importance to all who are concerned with land-use, including game,

fish, and recreational considerations, as well as agriculture, range management, and forestry, and certain phases of such important enterprises as soil and water conservation, fish and game administration, and farm and ranch management. Life-history studies, together with investigations of classification and distribution, constitute an important part of the foundation for work in this important new field.

METHODS

The importance of methods of study of mammalian life histories, and indeed of mammals in general and their other animal and plant associates, can scarcely be exaggerated. With proper and adequate methods the end result is sure. But standardization of methods is not only undesirable, it is impossible. Each species of mammal--or other animal or plant, for that matter--constitutes an individual species problem. Moreover, within a species there is much variation in response to surroundings, depending on age of the individual, geographical location, or other factors. For every species, every year, every time of year, and in every locality, different methods of study may be required. For each problem involving complicated organisms, as mammals in their environment, a unique set of methods may be required. Solution of the problem is likely to depend on invention or application of appropriate procedures. At best, manuals of ecological methods are only a point of departure in the development of ways and means for working out a given problem. Methods may well be studied and be standardized, but there will always remain a point beyond which standardization cannot go. The resourcefulness of the investigator will doubtless remain for all time to come his most important piece of equipment.

Relation of Field and Laboratory Methods

In the study of mammalian life histories, the use of both field and laboratory methods is abundantly justified. The possibility of a complete control of certain environmental factors under laboratory conditions sometimes leads to undue enthusiasm for this type of research. The value of laboratory investigations, however, may often be lessened by a loss of the normal response of the mammal.

With some mammals, which are of such size, number, and temperament that laboratory work with them is possible, studies like that of Yerkes (1907) with the dancing mouse may be counted on to yield results of the highest importance in respect to such problems as sense development and discrimination, habit formation, learning ability, and modifiability of behavior. The work of Sumner (1915), although largely concerned with problems of evolution and genetics, has afforded much information of value in studies of life history. Many mammals, however, cannot be so easily brought into the laboratory or successfully kept in captivity. The ideal method is for the life history student working in the open to carry his investigations into the laboratory whenever possible. The two fields are so vast and specialized, however, that this is rarely practicable. If adequate conclusions concerning behavior under actual living conditions are to be reached, it is necessary to associate work in the laboratory with direct observations of the animal in the natural state; and many of the most important details of animal life histories can never be learned in the laboratory.

Two authorities on this subject may be quoted here: Ritter (1917: 403) says, "The future's progress in the biological sciences will be accomplished by a far closer, more vital interdependence between researches out in nature and researches in the laboratory." Roosevelt (1917: 11) states, "It is essential to recognize that the best scientific men must largely work in the great out-of-doors laboratory of nature. It is only such outdoors work which will give us the chance to interpret aright the laboratory observations."

EQUIPMENT

Equipment needed for field investigations of habits of mammals varies all the way from tools that are available almost everywhere to the complicated and expensive instruments necessary to the solution of more difficult problems (Bailey 1912). Pick, shovel, ax or large hatchet, trowel or large spoon, brush cutter, grass cutter, tapeline, sketch pad, coordinate paper, field glasses, compass, camera, and writing materials usually suffice for beginning studies.

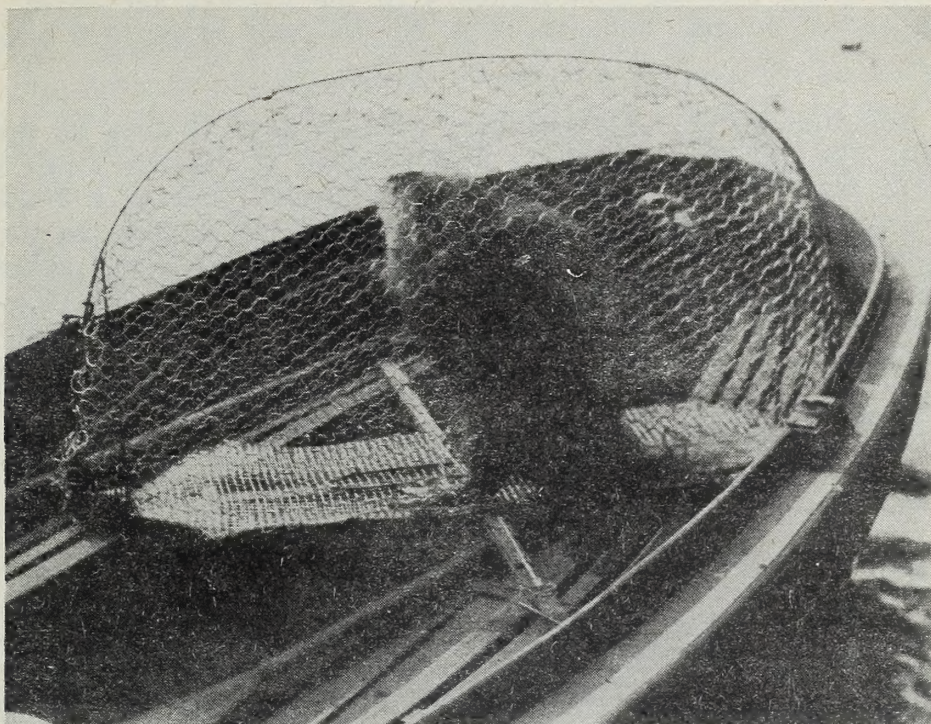
THE MODERN APPROACH

Less thorough modes of inquiry should give way as rapidly as practicable to intensive investigations of quantitative character. There is great need for the development of the ecologic method of approach in the study of the animal and its environment. Field plot or quadrat methods should be combined with observations on the behavior of animals under confinement, the whole based on a thorough knowledge of normal field conditions over wide areas. No attempt is made here to do more than refer to the development of this important side of the work, with the permanent field stations, specially trained personnel, and comparatively elaborate equipment that it implies. Development of new methods of study is one of the most important and promising lines of work in the entire field.

The increasing use of the camera in the study of habits is particularly desirable. Chapman (1900: 1) thus states the case for the scientific value of bird photography: "There are certain matters, such as a bird's song, its time of migration, etc., which must be set forth with the pen; there are others, such as its haunts, nesting site, nest, eggs, the appearance and development of its young, where the camera is so far ahead of the pen in its power of graphic representation that it is a waste of time to use the former when circumstances permit the utilization of the latter."

Though the camera is much less used in connection with mammal study, perhaps because of the nocturnal habits of some of these and the lesser accessibility of their haunts and homes, its value in this province can scarcely be overestimated. Photographs should be obtained of living animals in characteristic attitudes, of specimens (especially those freshly killed) of animals in live traps (fig. 1), of characteristic food plants or other vegetation, and of noteworthy features of topography or environment. Photographic record is desirable also of tracks of animals, their systems of runways, beds or shelters, nests, piles of stored food or "hay," feces, claw and tooth marks on trees, cropped vegetation, and general habitat. Present day animal portrait work is of such high quality that ordinarily it will not be possible for the biologist

in the field to attempt to equal it, but it is of such importance that whenever possible a professional animal photographer should be a member of a field party.



B-29083

Figure 1.--Live trapping is a very useful technic in getting life history data. A 42-pound beaver in trap.

Examples of Some Modern Approaches

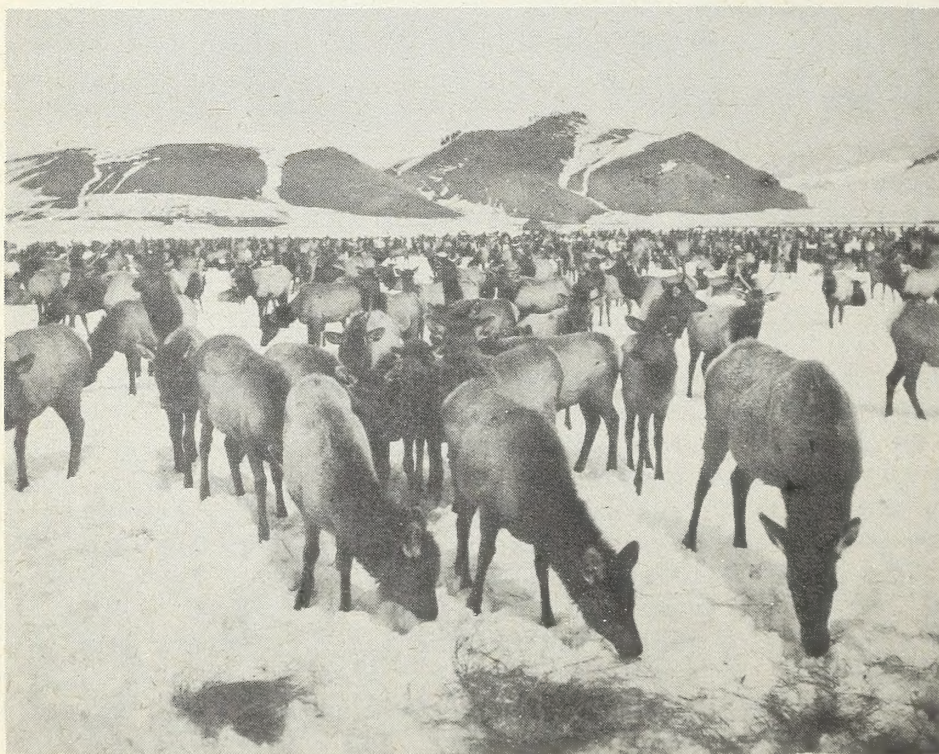
Horn (1938: 376) has emphasized the fact that certain seed-eating rodents show a decided preference for seeds of some conifers. In California forests, for example, he ^{2/} found that the preference is in the following order: Sugar pine, Jeffrey pine, ponderosa pine, white fir, and incense cedar. This preference is in the order of seed size, although that is not the deciding factor, as Horn points out, as the relative acceptability was the same when the seeds were reduced to a paste by grinding. The supply of sugar pine seeds is reduced by timber cutting. The consumption of the seeds by rodents is high. But white fir seeds are abundant. Seeds of the incense cedar are eaten only in small quantities by rodents. As a result, the sugar pine is being replaced by the less commercially valuable white fir and incense cedar. Here, then, is a case

^{2/} Horn, E. E. Some California wildlife-forest relationships. U. S. Dept. Int., Fish and Wildlife Service Wildlife Leaflet 275, 5 pp. July 1945. [Processed]

where mice and chipmunks are helping to alter profoundly the composition of some of the most important forests in the West (Taylor 1927: 392, 395-396, 398-399).

This relationship could have been satisfactorily discovered only through careful trapping and feeding experiments with the mammals concerned, associated with close observation over wide areas of forest land in various stages of management.

One of the most notable life-history studies made to date is that of A. A. Nichol (1938). He fed experimentally some 38 deer at various times in pens at the Santa Rita Experimental Range, near Tucson, Ariz., during a 3-1/2 year period to determine the food requirement necessary for growth, maintenance, and reproduction. Palatability tests were run on 168 different native plants. It was found that the coefficient 2.35 multiplied by the weight in hundreds of pounds of the deer will give in pounds the quantity of air-dry forage removed from the range daily by the deer. As Nichol points out, on any range on which there is to be cooperative use by both game and domestic stock, one of the first requisites to proper management is a knowledge of maintenance requirements of the species occupying the area. There is an urgent need for further work in the field.



B-20594

Figure 2.--Wintering concentrations of big game provide the opportunity for intensive observations. Elk on National Elk Refuge, Wyoming.

Someone has said that game counts are the heart of wildlife management. While it may be true in some places that determination of trends of population is sufficient; in others, actual numbers of the animals per area are essential if management is to be anything more than a theory (fig. 2). In a pasture, for example, where deer or other big game compete with livestock, the wildlife manager must know actual numbers per area in order to be able to advise properly concerning the adjustments necessary to keep the numbers of the wild game animals and the domestic livestock within the carrying capacity of the range. While many methods for determining the number of deer on an area have been tried, none has been fully satisfactory. Perhaps Bartlett (1938: 45-46), as well as others through repeated counts of areas surrounded by large numbers of men, has obtained the best results. But even in that method there is room for improvement.

Studies by Taylor, Vorhies, and Lister (1935) have shown that as the grazing ranges deteriorated and weeds replaced the better grass stages, certain forms of rodents increased in numbers. Thus the depletion of ranges by overgrazing by domestic stock may cause an increase in rodents. At the same time the augmenting numbers of range rodents may, in turn, have a bad effect on the forage.

An outstanding example of the study of a mammal (in this instance a species of big game) as a member of the biotic community is furnished by Rasmussen (1941) in his study of the problems presented on the Kaibab Plateau in northern Arizona. By defining the position of the mule deer in the plant-animal community and by careful analysis of surrounding conditions, Rasmussen has developed a number of convincing conclusions as to the potential far-reaching influence of a big game species on the vegetation.

Mention should also be made herein of the British work in the study of fluctuations in mammalian populations and some of the ecological implications involved (Elton 1942: 162). As all mammalogists recognize and appreciate, to Elton and his associates is due a large amount of credit for substantial advancement in our knowledge of this field. And what topic is more closely tied in with life histories than fluctuations in the population?

The "simple physiological fact" that in selecting food birds react to particular colors and rodents do not, which has been tested, is one of the outstanding recent discoveries in wildlife research. This trait can be made use of in a practical manner. It affords a method of differential use of grain by which seed-eating birds can be protected at the same time that rodents can be controlled. The tests devised by Kalmbach (1943) help to make the evidence conclusive. Here is another instance where experimental tests, using proper controls, develop information of practical value in management.

In his wildlife and habitat tally, Osborn (1943: 241-256) and his associates in the Soil Conservation Service have evolved a method for relatively quick appraisal of the number of animals on such large tracts as counties, watersheds, or project areas. Frequency of occurrence of game or other mammals on a sufficient series of 10-acre plots to be representative is relied on, rather than actual counts of animals on the whole area studied. The plan includes determinations of quality and quantity of food and cover available in all important

ecologic types and takes account of all observable mammals and birds as well as the principal plants in the area concerned. Attention is given to soils, and estimates are made of ecologic conditions essential for wildlife welfare during the most critical, as well as during the most favorable, season of the year.

Fischer, Davis, Iverson, and Cronemiller ^{3/} show how careful counting, determination of ecological relationships, and ascertainment of movements have resulted in a management plan for the herd of mule deer that migrates between southern Oregon and northern California. Political boundaries, prejudices of hunters, and complex administration may make the recommended remedies difficult to apply, but wildlife research based on what might be called ecological life histories has indicated what to do to obtain the best results.

Obviously something more than general terms is needed when an analysis of the types of vegetation used by mammals - perhaps more especially game mammals - becomes necessary. Workers like Soulen ^{4/} and Barick (1945) are helping to provide modern methods for analyzing habitat conditions, for example, of stream-sides for beavers and forest edges for deer and other animals.

In studying the food habits of the Texas beaver, Soulen devised a "beaver site survey," in the course of which detailed information was gathered on the species of trees present, including the number of trees of each species and the diameter and height of each (on an area one chain square), as well as similar information on the species and heights of shrubs and the number of stems in 1 by 12 inch transects taken at 5.5-foot intervals in a straight line back from the water's edge. He also counted the trees and shrubs per chain acre (an area one chain wide and 10 chains long). These details enabled him to express in quantitative terms the particular features that made some sites more favorable for beavers than others.

While Barick's (1945) analysis of forest edges does seem "formidably cumbersome," nevertheless it points the way toward a more exact understanding of the forest edges which are so important in game management. This habitat analysis, associated with studies of the mammals and other forms of animals which dwell, feed, and breed in the area concerned, throws new light on the community functioning in which the mammal or other creature takes part. Such analyses cannot be neglected in field studies directed toward the better understanding of mammalian life histories.

^{3/} Fischer, George A.; Davis, John C.; Iverson, Floyd; and Cronemiller, F. P. The winter range of the interstate deer herd, Modoc National Forest, California. U. S. Dept. Agr., Forest Service Region 5 report, 20 pp., illus. 1944. [Processed.]

^{4/} Soulen, Garrett H. Food habits of the Texas beaver (*Castor canadensis texanus*) as related to the State restoration program. Unpublished thesis. A. and M. College of Texas, Library, College Station, Texas.

Investigations of the immediate climatic environment of selected desert mammals by Vorhies (1945) have proved highly illuminating in relation to their ecology and physiology. In order to supplement observations with concrete data, use was made of a number of instruments, including soil thermographs and hygrothermographs, rain gauges, thermometers, and the psychrometer. Those interested in the life histories of any of the burrowing mammals, especially, should consult this paper.

By means of careful trapping, Blair (1940), Spencer (1941), and others have obtained important information regarding movements of Peromyscus and small rodents generally. Recently Stickel (1946a and 1946b), through an adroit combination of live-trapping, marking, snap-trapping, and removal of Peromyscus on tracts of known size, has shown that animals trapped on a one-acre tract in the middle of a 17-acre area were those whose normal ranges overlapped or closely approached the area. When these were removed from the area the animals taken in the central acre were in general those whose normal ranges were at successively greater distances. Mrs. Stickel has also emphasized some of the shortcomings in the current use of snap-trap data for determining actual population numbers. Her methods should apply widely, although differences in habits, trappability, and density of various species may influence and sometimes invalidate results. Unquestionably, experiments of this sort possess wide significance in such fields as rodent control and wildlife management.

Thus it is apparent that in the ever-increasing recognition of the mammal as a member of the biotic community, modern field workers are acquiring a more thoroughgoing appreciation of its role in the physiology of the community. This must of necessity apply also to the other animals, but even more important, to the plants. Field mammalogists should be familiar with such papers as those of Phillips (1931) and Taylor (1935b), which help to give the background and setting for all field studies of ecological life histories.

BACKGROUND DATA

Preparation for Work

The study of mammalian life histories opens a field of activity for any sincere student with an enthusiasm for closer acquaintance with wildlife. No human being or no book, but Nature herself, is the supreme authority in natural history. The beginner as well as the veteran investigator may make important observations, although training in scientific method and technic and broad experience are desirable for work on habits. At best, one can read all too little in "Nature's infinite book of secrecy."

Environment and Heredity

In a very real sense the mammal is the product of its surroundings, which on every side influences the individual, the community, and the species. Although there have been prolonged, critical, and thoroughgoing studies of heredity, similar investigations of the environment are for the most part lacking, so that the exact role of environment in the evolution and life of mammals is unknown. The numerous significant and interesting studies in genetics and

heredity seem to have resulted in too great an emphasis on the importance of heredity, often at the expense of environment. It is probable that field biologists, though conceding at once the importance of heredity, generally are in agreement with Jennings (1925: 48): "Any characteristic requires for its production both an adequate stock of chemicals and an environment adequate for its production through proper interaction of these chemicals with one another and with other things. In these senses all characteristics are hereditary and all are environmental, but no characteristic is exclusively hereditary or exclusively environmental." On pages 57 and 58 of this same 1925 publication, he says, "Heredity is stressed as all powerful; environment as almost powerless; a vicious fallacy, not supported by the results of investigation."

It is clear that the study of the relation of the environment to the development, structure, and habits of the living form is as well worthy of critical and prolonged attention as that which has been given to heredity in the past few decades.

Influences on Environment

The environment not only influences the mammal, but the mammal (as also virtually all other animals as well as plants) influences its environment through its multitudinous activities, as in loosening soil by burrowing and in excavating dens, burying rocks, packing soil by tramping and trail making, collecting materials for nests, building dams and flooding valleys, and scattering and planting seeds or destroying seeds and vegetation. Incorporation in the soil of organic materials, as skin, bones, flesh, and excreta, also may be included in these activities. Of course, the influence of one or of a few mammals ordinarily counts for little, but when the aggregate work of thousands and even millions of individuals is taken into account, the effects on environment are without doubt, in many instances, of great importance. The soil-building and fertilizing, or even the soil-destroying, role of different burrowing and terrestrial mammals remains to be determined. Christy (1884), Bell (1883), and Grinnell (1923: 145) have drawn attention to the significant parallel between the pocket gopher of North America and the earthworm in England as regards their work in soil formation. Studies of this and related subjects should be carried forward on a much broader scale than heretofore. It is inevitable, in the study of life habits, that effects of mammals on their surroundings should assume a prominent place (Taylor 1930, 1935a, 1935b, 1936).

Relations of Mammals and Plants

The influence of mammals on the distribution of plants is doubtless far more pervasive and important than has been realized. An intensive ecological study of the vegetation of a particular area has been made by Farrow (1925) in England. He writes (p. 104): "Apparently the presence of rabbits alone is sufficient to change the potentially dominant plant on Cavenham Heath from Pinus sylvestris [Scotch pine] to Pteris aquilina [brake] through a large number of various stages... The passing of England from a forest period into

a grassland period may of late have been accelerated by the influence of rabbits."

With the modified conditions brought on in the United States by lumbering, grazing, and agricultural practices, the relations of the native mammals to forest and forage are often fundamentally changed. In some localities the maintenance of a sustained yield of forest and forage, or the successful operation of specialized and intensive agricultural enterprises, will ultimately depend in large measure on the solution of problems in the life history and control of various mammals. Unfortunately the significance of mammals (and of vertebrates generally) in these matters has been generally neglected, as a perusal of projects and bibliographies shows. To work out these relations is manifestly impossible without close attention to mammalian life histories.

Life History of Mammals

The suggestions in this leaflet for studying the life history of mammals are divided so as to be applicable to the individual animal in its youth, maturity, and old age. Habits are known to change considerably at different stages of life, and such a division seems logical and justified by the demands for a better knowledge of the developing mammal.

After the principal life-history stages of the mammal have been studied, its structure and behavior are scrutinized more closely. Of special interest to the student of life habits are the form of the body as related to habits, special or noteworthy structural developments, and adaptations. Perhaps most of the work of the student of life histories, however, will be devoted to the behavior of the mammal, principally in nature, secondarily in the laboratory.

Relations of Lower Mammals and Man

Finally the relations of the lower mammals and man are considered. The means of finding and counting mammals are referred to, and the direct and indirect relationships hinted at. These relationships include the important effects of man's activities on wild mammals, and, conversely, the effects of the mammalian activities on man's interests. There is also suggested the possibility of undeveloped mammalian resources, as of new and unrecognized species of game flesh for food, and fur or hides for clothing.

SUGGESTED STUDIES

The points incorporated in the outline that follows are some of those concerning which additional detailed information is desirable. No one person can hope to acquire full information on all the items listed. The suggestions serve as a guide to what should be sought in the course of field work. They should also serve to encourage the recording of many facts that come to the notice of the observer, facts that are not ordinarily recorded because of their supposed unimportance. In general, the main headings alone will adequately serve the purpose of the investigator. In particular instances, however, the details listed under each heading may be found useful.

Almost any one of the suggestions included can be followed up and expanded with pleasure and profit (Coues 1877; Seton 1920), and will be found to possess a surprising degree of interest and often of practical importance.

For information regarding habits of the various mammals, the student is referred to Seton's Life-histories of Northern Animals (1909), his Lives of Game Animals (1925-1928), to Nelson's Wild Animals of North America (1918), and to the results of many special studies, including those published in the Journal of Mammalogy, Journal of Wildlife Management, and other scientific periodicals.

Environmental Influence on Mammals

A. Physical surroundings.

- (1) Soil--kind, composition, texture, color, depth; profile; chemical reactions, temperature and moisture at different depths; topography of region; general suitability for mammalian occupation or use; sand dunes, rocks, cliffs, caves.
- (2) Topography--direction and degree of slopes, exposure to sun and wind, amplitude and regularity of relief, relations to water bodies, plains, or other features (fig. 3).

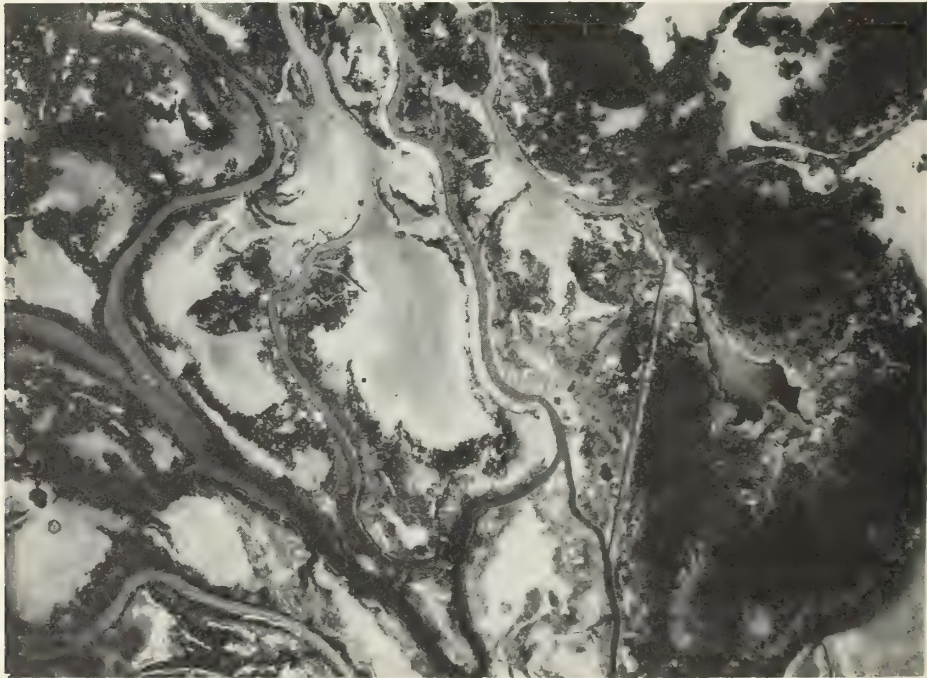


Figure 3.--Aerial photographs are useful to show topography, vegetative types, depths of water, and many other things. The white spots in the upper marshes are muskrat houses.

- (3) Water--amounts available, depth, composition, chemical reactions, currents, light, temperature, snow, ice.
- (4) Atmosphere--pressure, movements, temperature, moisture, light.
- (5) Changes in physical surroundings--relation of age-long changes in topography and climate to the development, migration, establishment, isolation, and extinction of the mammalian community.
- (6) Physical environment in relation to daily and seasonal activity--effects of weather, climate, and daily and seasonal cycles on the activity of the mammal (fig. 4), on hibernation, estivation, or other periodic phenomena, on nocturnal and diurnal activities, and on migration (regular or irregular); climate and fluctuations in numbers; effects of long days, very dark days, full moon, dark of the moon, and similar phenomena on habits; hours of activity and rest on part of different mammals; times of appearance and disappearance, as of bats.

B. Plant surroundings.

- (1) Plants of the land--above and below the surface; plants of the water.
- (2) Food and shelter relations between mammals and plants.
- (3) Mammals as disseminators of plants.
- (4) Mammals as checks on plant growth, as enemies of plants.
- (5) Plants causing irritation; infection and transmission of bacterial diseases to mammals and man; periodicity of contagious diseases in mammals; degree and rapidity of recovery; manner of recovery, natural medicines, healing substances or activities.
- (6) Relation between development of plants and animals.

C. Animal surroundings.

- (1) The mammal and its animal associates--in air, soil, water, trees, or on land; in burrows, dens, shelters, nests, trails, about water holes, salt licks, stamping grounds, or elsewhere.
- (2) Relation of the mammal and other animals--relation to others of same kind, to friends, partners, parasites, prey; associations with other individuals or groups; herding or flocking; competition and adaptation among animals; symbiosis, commensalism, warfare, as illustrated among mammals and their associates.
- (3) Animal-caused disease--effects; infection and transmission to other wild mammals, domestic animals, or man.

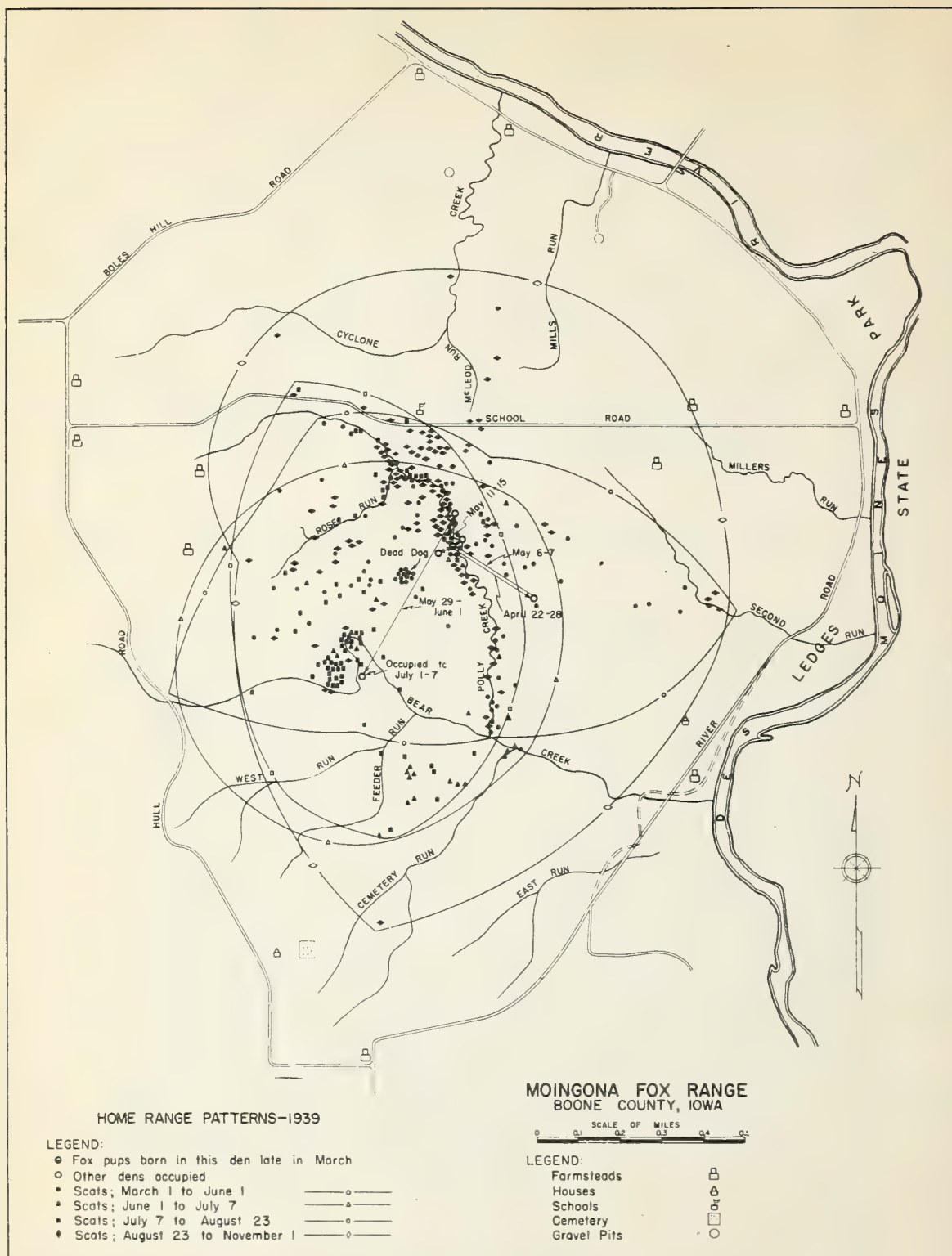


Figure 4.--Seasonal observations when plotted on a map indicate the ranges and habits of mammals. [Thomas G. Scott, 1943. Courtesy of Ecological Monographs.]

- (4) Relation of the individual mammal to the development of the community--mammals as related to the origin of communities and to such processes as migration, invasion or reinvasion, establishment, competition, dominance, extinction; mammals and ecological succession; primary and secondary succession; mammalian "weeds"; climax assemblages of mammals; factors governing distribution of mammals; effects of extreme or intermittent conditions on mammalian distribution; mammals and climatic cycles; mammalian numbers as affected by variations in forest, forage, wildlife, crop production.

Mammalian Influences on Environment

A. On physical surroundings.

- (1) Incorporation in soil of organic animal materials -- such as skin, hair, bones, antlers, horns, other organic materials, feces, urine.
- (2) Digging--formation of tunnels, holes, hollows, mounds; burial of rocks, logs, grass, or other objects by excavated materials; accumulation of materials for nests; storage of food; extent of cultivation of soil, the plowing effect of burrowing mammals; reduction of ditch banks, stream banks, or other topographic features by burrowing; general effects on erosion, beneficial, neutral, harmful; dimensions of tunnels and chambers, volume of earth removed.
- (3) Packing of soil by tramping or trail making.
- (4) Dam building and flooding of valleys.
- (5) Collection of materials for nests, with subsequent decay and soil building.
- (6) Effects on the soil of dissemination, planting, or removal of vegetation by mammals and of burying fertilizing materials.

B. On plant cover.

- (1) Use of miscellaneous plant parts, as stems, roots, leaves, twigs, or seeds for food (fig. 5), shelter, or nests--overgrazing; mammal-caused zones of vegetation about burrows, water holes, and other areas of concentration; activities of mammals in gnawing bark and eating cambium, girdling trees, or cutting down plants or trees.

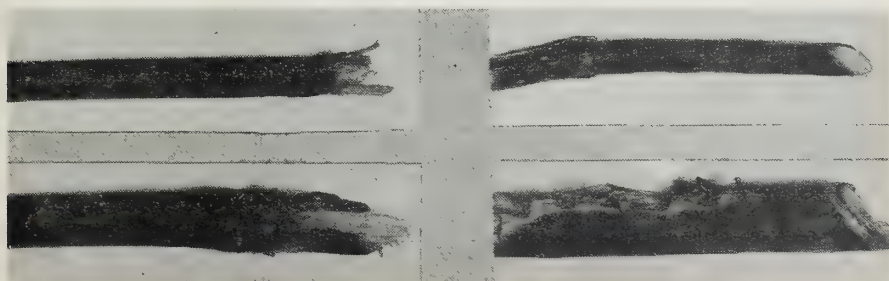


Figure 5.--Types of feeding often identify the mammal involved. Left: Deer browsing. Right: Rabbit gnawing.

- (2) Dissemination, storing, planting, or covering of vegetation by mammals.

C. On animals.

- (1) Capture and eating of prey--eggs, young, or adults of birds and reptiles (fig. 6); young or adults of mammals; of insects, fishes, mollusks, crustaceans, and other groups (fig. 7).

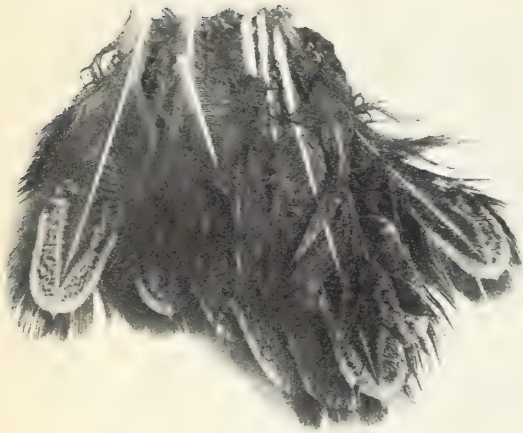


Figure 6.--Methods of feeding on prey species may identify the predator. Pheasant feathers sheared off by a red fox. [Thomas G. Scott, 1943. Courtesy, Ecological Monographs.



Figure 7.--Laboratory study of stomach and feces contents is a means of determining food habits.

- (2) Scattering of parasites or associated species.
- (3) Removal of vegetation--which often profoundly affects the other members of the community through disturbing their food and shelter relations.

Life History

A. Youth.

- (1) Birth--date, manner, and place of birth; weight of young and parents.
- (2) Number of young in a single litter; number of litters a year.
- (3) Structure and behavior--adaptation to protection and survival.
- (4) Growth--size, dimensions, weight, and stage of development at birth; ossification of bones; color of pelage; appearance of the skin, eyes, teeth, hair; senses; manner and rapidity of growth; date weaned; date of leaving nest; earliest age at which young are capable of survival without parents; date of achieving mature growth; age of sexual maturity; date of breeding.
- (5) Parental relations--condition and habits of young at birth as related to habits of parents; modes of feeding, carrying, and protecting young; manner of keeping young warm; special habits and instincts related to care of young; maladaptations in behavior toward young, as smothering or eating them; attitude of males toward young.
- (6) Enemies of young--severe weather and other physical phenomena; plant and animal enemies; diseases, parasites, insects, competitors; modes of opposing and escaping enemies; mortality rate of young.

B. Maturity.

- (1) Breeding--structures and habits as related to breeding; territory or home range; methods of procuring mates; evidence of sexual selection; courting antics; voice, songs or calls, behavior, odors as aids to mating; relations and relative numbers of the sexes; normal or abnormal increase in numbers, evidence of extraordinary reproduction; groupings or aggregations of young or old males, pregnant females, or others; dates of heat and copulation, associated habits; condition and distribution of mammae (mastology); length of period of gestation; place and manner of birth of young; length of suckling period; hybridization between related species; strength and duration of mating and family ties; polygamy, polyandry, promiscuity, monogamy; acquisition of harem; relation of parents to family; details of habits of parents during period of dependency of young; habits in reference to young, brooding, feeding, shielding, cleaning, providing with water, tending, guarding, carrying young to place of better shelter; adaptations and maladaptations in breeding habits; dates and manner of acquisition and loss of antlers or other structures related to breeding.
- (2) Nests, shelters, and other places of resort--natural resorts at different seasons; shelter chambers, bowers, lairs, dens, forms, beds; nests, storage chambers, chambers for deposit of excrement or for other purposes; purpose of nests, individual nests, associated nests, cooperative or composite nests, unoccupied nests; approaches to nests, burrows, tunnels, runways; protection or concealment of nests through closing

burrows or in other ways in the daytime or at night; habits associated with nest approach; regularity of use of bedding or nesting places; associates, such as insects, in dens or nests; earth packing in burrows; earth plugs, their structure and function; extent of den expansion; temperature studies of burrows and nests under different climatic and other environmental conditions at different depths and at different times of day, season, and year; numbers, plan, elevation, measurements of nests and nest chambers; technic for excavating and mapping dens; for reproduction or making casts of tunnels; measuring length and volume of tunnels.

- (3) Structure and behavior of mammals in nonbreeding condition--structures and habits observable in fall and winter; temperament, adaptations enabling mammal to endure stress of seasons; postbreeding migration, dispersal of families, flocking, wandering, food getting.
- (4) Size of adults; ossification of bones; coat color; other features in structure, behavior, or relationship peculiar to mature adults.

C. Old age.

- (1) Effect of old age on structure and behavior--general appearance of health, condition of teeth, coat, other external features; flocking or herding habits; hermits or recluses among mammals.
- (2) Food and shelter of the old.
- (3) Enemies, competitors, associates, means of cooperation and protection.
- (4) length of life; time, place, and manner of death.

Structure and Behavior

A. Structure.

- (1) Form of body--proportions, contour, weight, dimensions.
- (2) Special or noteworthy developments--head, trunk, tail, limbs, hands, feet, skin, hair, muscles, bones, glands, protective armor, sense organs, other noteworthy features.
- (3) Periodic structural changes--change with age, particularly ossification of bones, wear of teeth, branching of antlers, or development or modification of other appendages; periodic sexual changes; changes with season, molts, and growth, addition, increase, decrease, or loss of special appendages or organs.
- (4) Adaptations--overdevelopment or underdevelopment of bodily parts; markings or coloration--concealing, disruptive, directive, warning, mimicking; structures formerly beneficial, now harmful.

B. Behavior.

- (1) Disposition and temperament--individuality, gregariousness, intelligence, instinct, attitudes, strength, vitality, endurance, tenacity of life, courage, esthetic sense, sociability, playfulness, games, expression of emotions, moods, curiosity, memory, property instinct.
- (2) Senses--time and degree of development; reactions to sound, light, odor, taste, touch, balance; devices for appealing to senses, as voice, odor of urine, glands and their secretions (hip glands, metatarsal glands, back glands, belly glands, musk glands, foot glands, anal glands, sex glands); special sensory structures, as hairs, vibrissae, rhinaria, specialized skin, fleshy tactile appendages; attitudes in listening, touching, sniffing, looking, tasting; kinesthetic sense; homing sense; orientation.
- (3) Means of intercommunication--call notes of location, appeal, terror, courting, alarm, challenge, warning, concealment; barking, baying, screaming, howling, squeaking, squealing, singing, tapping, drumming, purring, roaring, bugling; warning attitudes; flash signals; emission of glandular secretions; odors and odor posts; touch.
- (4) Times of activity and leisure--hours of beginning and ending daily activity; times of appearance and disappearance, as of bats and other nocturnal species; unusual activity, as nocturnal species by day or diurnal species by night; hours of work, rest, sleeping, feeding, drinking; effects of weather on activities; attitudes, conditions, and locations when hunting, feeding, mating, playing, sunning, basking, resting, sleeping; differences in activities caused by temperature, moisture, wind, flood, storm.
- (5) Movements--in running, jumping, climbing, digging, swimming, flying; gaits, speeds; length of strides, height of jumps; endurance; holding or balancing objects; dexterity with "hands," feet, or tail; habits or tricks for protection or direction; time, place, and extent of travel; regularity of use of same travel way.
- (6) Eating and drinking--list of foods eaten indicating range of adaptability; foods at different seasons; food preferences; need for salt or other mineral materials; need for roughage; conveyance and storage of food; periods when stored food is used; food caches, as of mountain lions, bears, or rodents; times of harvesting and feeding; variations and reasons therefor; capacity for carrying or dragging food; quantities carried in cheek pouches, mouth, or paws; cleaning or washing of food; hay making and storing; quantities of food stored and eaten; effects of food getting on plant and animal surroundings; manner of capture of prey, chasing, sudden charging, lying in wait; manner of killing prey; "scratches" and caches; migration or movement in relation to prey; disposition after killing; portions eaten; manner of eating; cannibalism; dependence on water; time and manner of drinking; associated habits.

- (7) Sanitation--cleanly or uncleanly habits; place and manner of urination and defecation; condition of dens, nests, burrows, trails; bathing--dust baths, mud baths, sun baths, water baths; care of fur or hair, scratching, combing, cleaning, biting, personal toilet.
- (8) Flocking or nonflocking--solitary habits; gregariousness; association of the same or of different kinds of mammals in pairs, groups, or herds; seasonal aspects; whether groups are built about the family or are associations of individuals according to age, sex, or other conditions; advantages of groups; comparison of behavior of individuals alone and in herds; mob psychology; coordination of activities in group, synchronous responses to same stimulus.
- (9) Hibernation, estivation, and other periodic phenomena--dates of entering upon and emerging from hibernation and estivation; causes of hibernation and estivation, as related to altitude, climate, soil physiology, food, and water; weight, activity, and other characteristics of animals before, during, and after such period; details as to completeness or incompleteness of torpidity; occasional dormancy (controlling factors); movements or activities, and intermittent waking while hibernating or estivating; place of hibernation or estivation; habits associated therewith; body temperatures of hibernating or estivating mammals at different periods; temperatures of hibernating or estivating chambers, comparisons with outside temperatures; seasonal changes in food, in feces; hibernaria and other technical equipment for studying hibernating animals under controlled conditions.
- (10) Migration--movements of mammals, notably of bats, rodents, and ungulates; dates of appearance and disappearance; extent and direction of movements, local and general; causes of migration, food supply climatic, physiological; unusual migratory movements, as those caused by irruptions of lemmings and mice, and squirrel migrations, with conditions, causes, and extent.
- (11) Adaptations and maladaptations--intelligence; overdevelopment and underdevelopment of instinct; beneficial and harmful instincts; cooperation; movements and attitudes, freezing, slinking, running, crouching, hiding, trailing; shelter ways or avenues of retreat; conspicuous adaptation or lack thereof to new conditions; habits formerly beneficial, now harmful.
- (12) Miscellaneous peculiarities of habit--carrying propensities, as of wood rat; scratching and rolling habits, as of wolf, coyote, and mountain lion; other peculiarities.

Lower Mammals and Man

A. Finding and counting mammals.

- (1) Means of detecting presence of particular species--form of tracks, distances between footfalls, differences in tracks with various

speeds or movements, tracks in mud, dust, sand, snow; size of tracks as related to age and sex; feces (scatology), shape, size, color, composition, place of deposit, abundance; claw marks on trees, logs, or ground; tooth marks on wood or bone; cropped vegetation; characteristic "kills" by carnivorous species; identifying marks on birds' or reptiles' eggs disturbed by mammals; wallows, dust baths, beds, forms, nests, shelters, runways, holes, trails, yards, "using" places; cropped or harvested vegetation.

- (2) Numbers--present and former numbers; methods of taking inventory; counts on transects or unit areas; "surrounds," trap-night, live-traps, standard-bait, and poisoning methods of making counts; judging numbers from records of individuals seen, or from enumeration of tracks, feces per unit area, burrows, mounds, dens, nests, vegetation or other materials consumed, or other evidences of presence; fluctuations in numbers from year to year and causes of fluctuations; adverse or favoring conditions, storm, drought, or flood; effects of disease and other natural checks; manner and rate of increase in numbers.

B. Direct relations between mammals and man.

- (1) Effects on mammals of man's activities--increase or decrease in numbers due to man's occupation and invasion of new ranges, with changes in habits, involving changed relations to human welfare; effects on numbers, habits, and distribution of mammals of agriculture, railroad and bridge building and maintenance, dam building, canalization, fencing, hunting, grazing, lumbering, plowing and irrigating, drainage, forest fires, protection of certain species of game or other mammals, killing pest species, as predatory carnivores and rodents; effects of captivity; effects of war; utilization of game and fur species - present and former numbers; methods of conservation, restoration, and management; outlook for mammalian populations under present conditions of pressure from farming, grazing, predatory-animal control, hunting; manner of handling local legislation; hunting and trapping methods.
- (2) Undeveloped mammalian resources--flesh for food; fur or hides for clothing; other useful mammalian products; potential additional game species of mammals; possibilities and difficulties of domestication or semi-domestication or use of additional wild species.
- (3) Control of mammals--conditions under which mammals may become harmful; balance between harm done and possible benefits rendered by alleged pests (value as objects of sport, producers of fur, as sources of flesh for food, or as enemies of other species); rodents and other mammals as buffers, that is, to feed flesh-eaters and divert attention from game; details of economic relations, including lists of crops or products attacked, beneficial species preyed on, or of native vegetation or trees damaged; definite data on extent of damage done, conditions of damage; relation of damage to overgrazing or other activities for which man is responsible; economic relations

in different seasons; when and where are control methods justified; degree of control necessary on particular areas; methods of control, with details on trapping, poisoning, or hunting methods; control through improved manipulation of environment, as by altered cropping, forestry, range management, without the use of poison or other forms of killing; relation of mammals to public health, with data on parasites or disease germs carried by them and other susceptible animals (e.g., relation of rats and ground squirrels to bubonic plague; of rodents to Rocky Mountain spotted fever, Bullis fever, and typhus fever; of coyotes and other mammals to rabies; of rabbits, coyotes, and others to tularemia).

DISCUSSION

It is universally conceded that the work throughout, to be done well, must be founded on a taxonomic basis; but the time has arrived when a new emphasis may be placed on the intensive study of the living animal in its natural environment.

The outline presented in this leaflet indicates the richness of the field. To do it justice, the work of many individuals and institutions throughout the country will be required. On the taxonomic side, each State should have at least one representative collection of the mammals and other vertebrates to be found within its borders. The building up of private collections should likewise be encouraged. There are still great gaps in the material representative of the larger groups of mammals and of most of the smaller ones, even in the larger collections in this country.

But the incompleteness in our information regarding life histories and interrelationships is even more conspicuous. Universities, colleges, normal and high schools, State scientific surveys, National, State, and city museums, and National and State associations and commissions for the protection of fish and game, as well as the United States Departments of Agriculture and of the Interior, all have an opportunity to serve their respective constituencies and the country in this field. 5/

5/ The Fish and Wildlife Service, U. S. Department of the Interior, solicits correspondence from any individual or institution planning work on the relationship of life histories of mammals or birds, and will be glad to assist with advice or suggestions as opportunity may be given.

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